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AIRCRAFT GROUND-FLOTATION INVESTIGATION

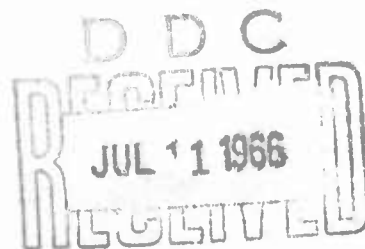
PART III. DATA REPORT ON TEST SECTION 2

W. BRABSTON, A. RUTLEDGE, and W. HILL

U. S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION

TECHNICAL REPORT AFFDL-TR-66-43, PART III

APRIL 1966



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AIRCRAFT GROUND-FLOTATION INVESTIGATION

PART III. DATA REPORT ON TEST SECTION 2

W. BRABSTON, A. RUTLEDGE, and W. HILL

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FOREWORD

The investigation described herein constitutes one phase of studies conducted during 1964 and 1965 at the U. S. Army Engineer Waterways Experiment Station (WES) under U. S. Air Force Project No. 410-A, MIPR No. AS-4-177, "Development of Landing Gear Design Criteria for the CX-HLS Aircraft." (The CX-HLS is now designated C-5A.) This program was sponsored and directed by the Landing Gear Group, Air Force Flight Dynamics Laboratory, Research and Technology Division, Mr. R. J. Parker, Project Engineer.

These tests were conducted by personnel of the WES Flexible Pavement Branch, Soils Division, under the general supervision of Messrs. W. J. Turnbull, A. A. Maxwell, and R. G. Ahlvin, and the direct supervision of Mr. D. N. Brown. Other personnel actively engaged in this study were Messrs. C. D. Burns, D. M. Ladd, W. N. Brabston, A. H. Rutledge, H. H. Ulery, Jr., A. J. Smith, Jr., and W. J. Hill, Jr. This report was prepared by Messrs. Brabston, Rutledge, and Hill.

Directors of the WES during the conduct of this investigation and preparation of this report were Col. Alex G. Sutton, Jr., CE, and Col. John R. Oswalt, Jr., CE. Technical Director was Mr. J. B. Tiffany.

Publication of this technical documentary report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

FOR THE DIRECTOR

GEORGE A. SOLT, JR.
Actg Chief, Mechanical Branch
Vehicle Equipment Division
AF Flight Dynamics Laboratory

ABSTRACT

This data report describes work undertaken as part of an overall program to develop ground-flotation criteria for the C-5A aircraft. A test section was constructed to a width adequate for two similar test lanes. Each lane was divided into three items having different subgrade CBR values and different traffic surfaces. Item 1 was surfaced with modified T11 aluminum landing mat, item 2 with M8 steel landing mat, and item 3 remained unsurfaced. Traffic was applied to one lane using a 35,000-lb load on a single-wheel assembly consisting of one 56x16, 24-ply aircraft tire inflated to 100 psi. On the other lane a twin-wheel assembly (loaded to 70,000 lb) consisting of two 56x16, 32-ply aircraft tires spaced 25 in. c-c and inflated to 110 psi was used.

This report presents a description of the test section and wheel assemblies, and gives results of traffic. The traffic-coverage level at which failure was evidenced on each test item is also given.

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SUMMARY

Tests on test section 2 are one phase of a comprehensive research program to develop ground-flotation criteria for heavy cargo-type aircraft. Section 2 consisted of two similar traffic lanes, lanes 3 and 4, each of which was divided into three items (**Fig 26**). Each item was constructed to a different subgrade CBR value and had a different traffic surface. Item 1 was surfaced with modified T11 aluminum landing mat, item 2 with M8 steel landing mat, and item 3 remained unsurfaced.

Traffic was applied to lane 3 using a 35,000-lb load on a single-wheel assembly consisting of one 56x16, 24-ply aircraft tire with inflation pressure of 100 psi. On lane 4, a twin-wheel assembly (loaded to 70,000 lb) consisting of two 56x16, 32-ply aircraft tires spaced 25 in. c-c and inflated to 110 psi was used. The lanes were trafficked to failure in accordance with the criteria designated in Part I of this report. Data were recorded throughout testing to give a behavior history of each item.

Data on test section 2 provide a direct comparison of trafficking effects of a single-wheel assembly and a twin-wheel assembly having double the test load of the single-wheel assembly. Basic performance data are summarized in the following paragraphs.

Lane 3

Item 1

The item was judged failed at 600 coverages due to excessive roughness. The rated CBR for the item was 2.6.

Item 2

The item was judged failed at 120 coverages due to roughness. Traffic was continued and data were recorded to 200 coverages. The rated CBR for the item was 5.1.

Item 3

The item was judged failed at 60 coverages due to excessive rutting. To observe postfailure behavior, traffic was continued to 122 coverages.

The rated CBR of the item was 9.5.

Lane 4

Item 1

At 20 coverages the item was judged failed due to roughness and subgrade failure. The rated CBR of the item was 2.3.

Item 2

At 20 coverages the item was judged failed due to excessive roughness. The rated CBR of the item was 3.6.

Item 3

The item was judged failed at 20 coverages due to excessive roughness. The rated CBR of item 3 was 10.

AIRCRAFT GROUND-FLOTATION INVESTIGATION

PART III DATA REPORT ON TEST SECTION 2

SECTION I: INTRODUCTION

The investigation reported herein is one phase of a comprehensive research program being conducted at the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., as part of U. S. Air Force Project 410-A, MIPR No. AS-4-177, to develop ground-flotation criteria for the C-5A, a heavy cargo-type aircraft. Specifically, the tests reported herein are part of a series of tests to determine the degree of interaction of the wheels of multiple-wheel landing-gear assemblies on landing mat and unsurfaced soils under various conditions of loading.

Prosecution of this investigation consisted of constructing two similar traffic lanes and subjecting them to two different load and wheel assembly combinations. Test results provide a direct comparison of trafficking effects of a single-wheel assembly and a twin-wheel assembly having double the test load of the single-wheel assembly.

This report presents a description of the test section and wheel assemblies, and gives results of traffic. Equipment used, types of data and method of recording them, and general test criteria are explained and illustrated in Part I of this report.

Description of Test Section

The test section (**Fig 26**) was constructed within a roofed area in order to allow control of the subgrade CBR (California Bearing Ratio) in the test items. Construction of the test section was accomplished by first excavating a 54- by 110-ft area to a depth of 6 ft. The excavated area was backfilled to the original grade level in compacted lifts with a heavy clay soil (buckshot; classified as CH according to the Unified Soil Classification System, MIL-STD-619) having a plastic limit of 27, liquid limit of 58, and plasticity index of 31. Gradation and classification data for the subgrade material are given in Part I. **Fig 26** presents a longitudinal section of the test section subgrade showing the average soil strengths as constructed.

Two traffic lanes divided into three items each were constructed in the section. Different subgrade strengths were obtained in the items (**Fig 26**) by controlling the water content and compaction effort. Items 1 and 2 were surfaced with modified T11 aluminum and M8 steel landing mats, respectively (see **Fig 27**). Item 3 remained unsurfaced. The landing mats used are described and illustrated in Part I.

Load Vehicle

The load vehicle used in trafficking test section 2 is shown in **Figure 2**. Load cart construction, details of linkage between the load compartment and prime mover, and method of applying load are presented in Part I. For trafficking lane 3, the load compartment was weighted to produce a load of 35,000 lb on the single wheel. For trafficking lane 4, a 70,000-lb load was used on a twin-wheel assembly. A 56x16, 24-ply aircraft tire (**Fig 28**) with inflation pressure of 100 psi was used on lane 3. Two 56x16, 32-ply aircraft tires (**Fig 28**) inflated to 110 psi and spaced 25 in. c-c were used on lane 4. Tires with different ply ratings were used because three tires with the same rating were unavailable. To obtain approximately the same tire contact areas, a higher inflation pressure was used for the 32-ply tires. It was considered that these differences would have a negligible effect on the test results.

SECTION III: APPLICATION OF TRAFFIC AND FAILURE CRITERIA

Application of Traffic

The load vehicle was operated to produce uniform traffic coverage on the test lanes. The load cart was driven forward and backward along the same track longitudinally along the test lane, then shifted laterally and the forward-backward operation repeated. In this manner, two coverages of traffic were applied to the test lane as the vehicle progressed from one side of the lane to the other. Figure 1 shows the general method of applying uniform coverages on the test lanes. Typically, the lane widths used were not exact multiples of the tracking tire widths and spacings so that it was necessary to determine a coverage factor for each lane to compensate for small overlaps or gaps in the traffic coverage pattern. In all cases, the coverage levels indicated in the text and on the data sheets represent the corrected coverage levels.

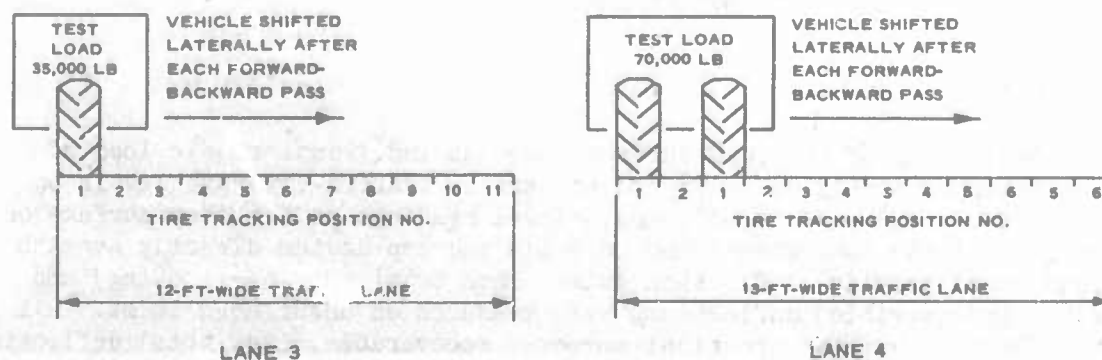


Figure 1. Sequence of traffic application for uniform coverages

Failure Criteria

Failure criteria used in this investigation and descriptive terms used in presentation and discussion of data in all reports in this series are presented in Part I. A general outline of types of data collected is given in the following paragraphs. Details of apparatus and procedure for obtaining specific measurements are given in Part I.

CBR, water content, and dry density

CBR, water content, and dry density of the subgrade were measured for each test item prior to application of traffic, at intermediate coverage levels, and at failure or suspension of traffic if no failure condition was reached. After traffic was concluded on an item, a measure of subgrade strength termed "rated CBR" was determined. Rated CBR is generally the average CBR value obtained from all the determinations made

in the top 12 in. of soil during the test life of an item. In certain instances, extreme or irregular values may be ignored if the analyst decides that they are not properly representative.

Surface roughness, or differential deformation

Surface roughness, or differential deformation, measurements were made using a 10-ft straightedge at various traffic-coverage levels on all items. Rut depths were measured for unsurfaced items, and dishing effects of individual mat panels in the mat-surfaced items were recorded.

Deformations

Deformations, defined as permanent cumulative surface changes in cross section or profile of an item, were charted by means of level readings at pertinent traffic-coverage levels.

Deflection

Deflection of the test surface under an individual static load of the tracking assembly was measured at various traffic-coverage levels on both surfaced and unsurfaced items. Level readings on the item surface on each side of the load wheels and on a pin and cap device directly beneath a load wheel provided deflection data. Both total (for one loading) and elastic (recoverable) deflections were measured on unsurfaced items. All mat deflection was for practical purposes recoverable, i.e. total deflection equaled elastic (spring-back) deflection. The pin and cap device for measuring deflection directly beneath load wheels was applied to the sub-grade of surfaced items through a hole (existing or cut) in the mat.

Rolling resistance

Rolling resistance, or drawbar pull, measurements were performed with the load vehicle over each test item at designated coverage levels. Three types of drawbar measurements were taken: (a) maximum force required to overcome static inertia and commence forward movement of the load cart, termed "initial DBP"; (b) average force required to maintain a constant speed once the load vehicle is in motion, termed "rolling DBP"; and (c) maximum force obtained during the constant speed run, termed "peak DBP."

Mat breaks

Mat breaks on the surfaced items were inspected, classified by type, and recorded on the data sheet at various coverage levels.

SECTION IV: BEHAVIOR OF ITEMS UNDER TRAFFIC AND TEST RESULTS

Lane 3

Behavior of items under traffic

Item 1. A general view of item 1 prior to traffic is shown in **Figure 3**. Prior to 200 coverages, displacement of subgrade at the transition between item 1 and the previously failed item 2 (see profile in **Figure 29**) became evident. At 458 coverages, it became necessary to remove mat runs 15 through 19 (**Fig 27**) and level the subgrade prior to mat replacement. **Figures 5 and 6** show the hump which had developed at the transition. After replacement, the five affected mat runs were no longer considered in performance evaluation, as transition zones are not considered representative of item condition. Item 1 was judged failed at 600 coverages due to excessive roughness (**Figures 7 and 8**). The rated CBR was 2.6.

Item 2. Item 2 is shown prior to traffic in **Figure 8**. By 20 coverages, bending of the mat panels along their long axis resulted in a "standoff" of the mat from the subgrade at the end joints of the mat panels. Embedment of the mat at midpoint of the panels remained good. The ductility of the M8 mat allowed a wide variation in the degree of embedment of the ends of the mat panels. Immediately following a pass by the load wheel directly over the mat end joints, reasonable embedment was attained. However, the ends of the panels became unembedded after a pass off the line of joints. At 120 coverages, the item was considered failed due to roughness (**Figures 9 and 10**). Traffic was continued beyond 200 coverages to observe postfailure behavior of the mat (**Figure 11**). The rated CBR for item 2 was 5.1.

Item 3. Item 3 is shown in **Figure 12** prior to trafficking. Ruts had begun to develop by 20 coverages (**Figure 13**), and at 60 coverages the ruts were severe enough to constitute failure of the item (**Figure 14**).

To observe postfailure behavior of the item, traffic was continued to 122 coverages. **Figure 15** shows the poor condition of the item after 62 postfailure coverages. The rated CBR of the item was 9.5.

Test results

Table 1 summarizes traffic data recorded on each item of lane 3 during testing. Soil test data are given in table 2.

Item 1. Item 1 was considered failed due to roughness at 600 coverages. The following information was obtained from traffic tests on item 1.

- a. Roughness. At failure, the maximum transverse and diagonal differential deformations were 1.75 and 2.25 in., respectively.

Table 1 gives differential deformations and maximum dishing at intermediate levels of coverage. Maximum dishing of individual panels was 0.50 in.

- b. Deformation. Average profile and cross-section deformation plots are shown in plates 4 and 5, respectively, for several coverage levels. General subsidence of the traffic lane is evident in each of the plots. A maximum average cross-section deformation of 2.3 in. was measured at failure (Fig 30).
- c. Deflection. Fig 31 illustrates the mat deflection under static load of the wheel assembly at various coverage levels with center line of the assembly located at different points relative to panel joints. The largest deflection (2.3 in.) was recorded with the load wheel resting on a panel end joint at 600 coverages. At the same coverage level, the pin and cap device showed the elastic subgrade deflection to be 1.5 in. directly beneath the load wheel at the midpoint of a panel.
- d. Rolling resistance. Initial, peak, and rolling drawbar pull values showed large increases with continued trafficking. Table 1 shows drawbar pull values for several coverage levels.
- e. Mat breaks. The number and type of mat breaks are given in table 1. Breakage did not impair performance of the T11 mat.

Item 2. Item 2 was considered failed due to roughness at 120 coverages. Traffic was continued to 200 coverages to obtain postfailure data. The following information was obtained from traffic tests on item 2.

- a. Roughness. At failure, the maximum transverse and diagonal differential deformations were 1.50 and 2.00 in., respectively (table 1). Table 1 also gives differential deformation at intermediate and postfailure coverage levels. The maximum dishing for item 2 (table 1) was 0.56 in.
- b. Deformation. Average profile and cross-section deformation plots are shown in Figs 29 and 30, respectively, for three different coverage levels. The inconsistency observed in the profile plots for item 2, lane 3, where the 120-coverage points are higher than the 0-coverage points is thought to be due to the standoff effect (mentioned on page 5) caused by the last pass of the load wheel being made off the joint line. Cross-section plots in Fig 30 show the progressive increase in deformations with traffic coverages and illustrate the upheaval that was prevalent at panel joints.
- c. Deflection. Fig 31 illustrates mat deflections under static load of the load wheel at various coverage levels with the center line of the assembly located at different points relative to panel joints. Elastic subgrade deflections (table 1) remained between 0.5 and 0.6 in. throughout trafficking. Subgrade deflection

measurements were made with pin and cap device when the load wheel was centered at the quarter point of mat panel.

- d. Rolling resistance. Initial, peak, and rolling drawbar pull values (table 1) increased with traffic coverages.
- e. Mat breaks. Few mat breaks were observed during trafficking. Table 1 shows the number of each type of mat break that occurred.

Item 3. Item 3 was considered failed due to excessive rutting at 60 coverages. Traffic was continued to 122 coverages at which time drawbar pull values were recorded and photographs were taken of the postfailure condition. The following information was obtained from traffic tests on item 3.

- a. Roughness. Table 1 shows the progressive development of differential deformation. The maximum differential deformation of 2.5 in. was recorded with the 10-ft straightedge in a diagonal position. The maximum rut depth measured was 2.5 in.
- b. Deformation. Average cross-section deformations for 20 and 60 coverages are plotted in Fig 30. A center-line profile representing the same coverages is shown in Fig 29. The plots in both plates show progressive subsidence of the traffic lane.
- c. Deflection. Total soil deflection under static load of the load wheel is represented in Fig 31. At 0 coverages the elastic deflection (table 1) was 0.3 in. and at 60 coverages elastic deflection was 0.9 in.
- d. Rolling resistance. Small increases in initial, peak, and rolling drawbar pull values (table 1) were measured as coverage levels increased.

Lane 4

Behavior of items under traffic

Item 1. Item 1 prior to traffic is shown in Figure 16. At 12 coverages, mat breaks were observed, especially along the center lines of the panels where sheared rivets were common. Types and number of mat breaks are given in table 1. Deterioration of the mat was rapid with additional traffic coverages and the item was considered failed due to roughness and subgrade failure at 20 coverages (Figures 17 and 18). The rated CBR was 2.3.

Item 2. Item 2 prior to traffic is shown in Figure 19. Preliminary passes of the load cart over the item to record drawbar pull data caused considerable extrusion of subgrade soil through the tubular holes of the M8 mat, as shown in Figure 20. At 20 coverages the item was

considered failed due to the large amount of subgrade extrusion which caused surface roughness and mat deformations (Figures 21 and 22). No mat breakage was found at failure. Figure 23 shows the deformed mat surface after removal of the extruded soil. The rated CBR of the item was 3.6.

Item 3. Figure 24 shows item 3 prior to traffic. At 20 coverages the item was considered failed due to severe rutting (Figure 25). The rated CBR for the item was 10.

Test results

Table 1 summarizes traffic data recorded for each item of lane 4. Soil test data are given in table 2. Table 1 also shows drawbar pull values for the load vehicle operated over an asphalt strip for comparison with drawbar values recorded on the test lane.

Item 1. Item 1 was considered failed due to roughness at 20 coverages. The following information was obtained from traffic tests on item 1.

- a. Roughness. At failure, the maximum differential deformations exceeded 3 in. for each position of the 10-ft straightedge. A maximum diagonal differential deformation of 4 in. was recorded. Dishing of individual panels was pronounced, reaching a maximum of 1.8 in.
- b. Deformation. Average profile and cross-section deformations are shown in Figs 29 and 30, respectively. The maximum deformations occurred along the joint line 1 ft west of the center line. Fig 30 shows a maximum cross-section deformation of 1.9 in. for the item. The profile plots in Fig 29 illustrate the severe deformation and roughness that occurred along the direction of traffic.
- c. Deflection. Elastic mat deflections under the static load of the test cart are represented in Fig 31. Mat and subgrade deflections are tabulated in table 1. Plots in Fig 31 show mat configuration with load wheels in various positions relative to panel end joints. In each instance, the mat deflections were significantly greater at the 20-coverage level than those measured prior to trafficking. The elastic subgrade deflection measured at failure was 1.9 in.
- d. Rolling resistance. Initial, peak, and rolling drawbar pull values (table 1) showed small increases up to the 20-coverage level.
- e. Mat breaks. A large number of breaks occurred as the mat deteriorated with traffic to the 20-coverage level. Number and types of breaks are tabulated in table 2; description and examples of each type are given in Part I of this report.

Item 2. Item 2 was considered failed due to roughness at 20 coverages. A large amount of soil was extruded through the M8 mat holes, thus contributing to roughness through uneven subsidence of the mat and buildup of soil on the mat surface. The following information was obtained from traffic tests on item 2.

a. Roughness. At failure, the maximum transverse and diagonal differential deformations were 3.1 in. (table 1). Dishing of individual panels was slight, reaching a maximum of 0.5 in. at 20 coverages.

b. Deformation. Average profile and cross-section deformations are shown in Figures 29 & 30, respectively. Maximum deformation occurred along a line near the end joints on the west side of the lane.

c. Deflection. Elastic mat deflections under static load of the test cart are represented in Fig 31. Mat deflections are plotted for three positions of the wheel assembly relative to panel end joints. Maximum mat deflection occurred at the center line of the wheel assembly. Tabulated values of mat deflection and subgrade deflection are given in table 1. The elastic subgrade deflection was 0.8 in. prior to traffic and at failure.

d. Rolling resistance. Table 1 gives initial, peak, and rolling drawbar pull values at 0 and 20 coverages. For each case, drawbar pull values showed an increase at 20 coverages.

e. Mat breaks. No mat breaks were found at failure of the item, as the M8 mat had sufficient flexibility to conform to the deformed subgrade surface without breaking.

Item 3. Item 3 was considered failed due to severe rutting at 20 coverages. The following information was obtained from traffic tests on item 3.

a. Roughness. Maximum transverse and diagonal differential deformations (table 1) reached 5.8 and 5.1 in., respectively, at 20 coverages. Rut depth was 5.6 in. at failure.

b. Deformation. Average cross-section deformations are plotted in Fig 30 for the 20-coverage level. Significant changes in the cross section occurred with each pass of the load vehicle due to severe rutting beneath the load wheels. The profile plot in Fig 29 indicates a general subsidence along the longitudinal direction of the traffic lane.

c. Deflection. Soil deflections under static load of the load wheels are represented in Fig 31. Elastic deflections (table 1) were greater at 0 coverages than at the 20-coverage level.

d. Rolling resistance. The drawbar pull values in table 1 illustrate the increases in initial, peak, and rolling resistance that occurred with trafficking.

SECTION V: PRINCIPAL FINDINGS

From the foregoing discussion, the principal findings relating test load, wheel assembly, tire inflation pressure, surface type, subgrade CBR, and traffic coverages are as follows:

<u>Load, Wheel Assembly, and Tire Pressure</u>	<u>Type of Surface</u>	<u>Rated Subgrade CBR</u>	<u>Coverages at Failure</u>
35,000-lb load; single-wheel assembly; 56x16, 24-ply tires at 100-psi inflation pressure	Modified T11 aluminum mat	2.6	600
	M8 steel mat	5.1	120
	Unsurfaced	9.5	60
70,000-lb load; twin-wheel assembly; 25-in. c-c, 56x16, 32-ply tires at 110-psi in- flation pressure	Modified T11 aluminum mat	2.3	20
	M8 steel mat	3.6	20
	Unsurfaced	10.0	20

TABLE 1
SUMMARY OF TRAFFIC DATA, TEST SECTION 2

Test Item	Cover- ages	Rated CR	No. of Mat Breaks A B C D E	Max Differential Deformation (in.) Longitudinal Trans- versal	Max Dishing or Rutting (in.)	Drawbar Pull (lbs) Initial Final Peak	Average Total Deflection (in.)						Remarks
							with Center Line of Assembly Located on Unsurfaced Quarter Point		Half Point		Joint		
							Center Line of As- sembly	Max	Center Line of As- sembly	Max	Center Line of As- sembly	Max	
Lane 3													
Modified T11 aluminum landing mat	0	0	1	0.25	0.50	1.75	2.90	1.05	1.1	1.2	1.3	Failure due to roughness at 600 coverages	
	20	20	2	0.50	0.88	2.68	2.80	1.20	1.2	1.7			
	50	50	4	0.50	0.94	2.65	2.30	1.30	1.2	1.8			
	80	80	7	0.50	0.94	4.20	3.10	1.60	1.2				
	100	100	11	0.50	0.63	5.70	3.70	1.70	1.4	1.9			
	120	120	13	0.50	0.63	5.70	3.70	1.70	1.3				
	150	150	21	0.50	0.63	5.70	3.70	1.70	1.3				
	200	200	21	0.50	0.63	5.70	3.70	1.70	1.3				
	300	300	21	0.50	0.63	5.70	3.70	1.70	1.3				
	400	400	21	0.50	0.63	5.70	3.70	1.70	1.3				
No 2 steel landing mat	0	0	1	0.25	0.50	1.60	2.80	1.10	0.8	1.1	1.4	Failure due to roughness at 120 coverages. Traffic continued to ob- serve postfailure behavior	
	20	20	2	0.50	0.88	2.83	2.80	1.25	1.2	1.2	1.4		
	50	50	4	0.50	0.94	3.33	2.90	1.35	1.2	1.2	1.4		
	80	80	7	0.50	0.94	5.70	3.70	1.70	1.2	1.2	1.4		
	100	100	11	0.50	0.63	5.70	3.70	1.70	1.2	1.2	1.4		
	120	120	13	0.50	0.63	5.70	3.70	1.70	1.2	1.2	1.4		
	150	150	21	0.50	0.63	5.70	3.70	1.70	1.2	1.2	1.4		
	200	200	21	0.50	0.63	5.70	3.70	1.70	1.2	1.2	1.4		
	300	300	21	0.50	0.63	5.70	3.70	1.70	1.2	1.2	1.4		
	400	400	21	0.50	0.63	5.70	3.70	1.70	1.2	1.2	1.4		
Unsurfaced	0	0	1	0.25	0.50	2.60	3.60	1.20	1.1	1.1	1.4	Failure due to excessive rutting at 60 cover- ages. Traffic contin- ued to 122 coverages to observe post- failure behavior	
	20	20	2	0.50	0.88	2.48	2.60	1.60	1.1	1.1	1.4		
	50	50	4	0.50	0.94	3.60	5.70	1.90	1.7	1.7	1.4		
	80	80	7	0.50	0.94	5.70	4.60	2.20	1.1	1.1	1.4		
	100	100	11	0.50	0.63	5.70	3.70	1.70	1.1	1.1	1.4		
	120	120	13	0.50	0.63	5.70	3.70	1.70	1.1	1.1	1.4		
	150	150	21	0.50	0.63	5.70	3.70	1.70	1.1	1.1	1.4		
	200	200	21	0.50	0.63	5.70	3.70	1.70	1.1	1.1	1.4		
	300	300	21	0.50	0.63	5.70	3.70	1.70	1.1	1.1	1.4		
	400	400	21	0.50	0.63	5.70	3.70	1.70	1.1	1.1	1.4		
Modified T11 aluminum landing mat	0	0	1	0.25	0.50	11.44	7.20	4.02	3.2	2.8	2.9	Failed at 20 coverages due to roughness	
	20	20	2	0.50	0.88	12.57	10.60	6.97	3.8	3.1	4.4		
	50	50	4	0.50	0.94	7.64	7.05	3.85	2.0	2.0	2.4		
	80	80	7	0.50	0.94	8.97	7.20	5.43	2.4	2.5	2.4		
	100	100	11	0.50	0.63	6.70	5.90	4.00	2.4	2.0	2.4		
	120	120	13	0.50	0.63	9.70	8.80	6.47	2.4	2.5	2.4		
	150	150	21	0.50	0.63	7.95	5.40	3.00	2.4	2.5	2.4		
	200	200	21	0.50	0.63	7.95	5.40	3.00	2.4	2.5	2.4		
	300	300	21	0.50	0.63	7.95	5.40	3.00	2.4	2.5	2.4		
	400	400	21	0.50	0.63	7.95	5.40	3.00	2.4	2.5	2.4		
No 2 steel landing mat	0	0	1	0.25	0.50	6.70	5.90	4.00	2.0	2.0	2.4	Failed at 20 coverages due to roughness	
	20	20	2	0.50	0.88	9.70	8.80	6.47	2.4	2.5	2.4		
	50	50	4	0.50	0.94	7.95	5.40	3.00	2.4	2.5	2.4		
	80	80	7	0.50	0.94	7.95	5.40	3.00	2.4	2.5	2.4		
	100	100	11	0.50	0.63	7.95	5.40	3.00	2.4	2.5	2.4		
	120	120	13	0.50	0.63	7.95	5.40	3.00	2.4	2.5	2.4		
	150	150	21	0.50	0.63	7.95	5.40	3.00	2.4	2.5	2.4		
	200	200	21	0.50	0.63	7.95	5.40	3.00	2.4	2.5	2.4		
	300	300	21	0.50	0.63	7.95	5.40	3.00	2.4	2.5	2.4		
	400	400	21	0.50	0.63	7.95	5.40	3.00	2.4	2.5	2.4		
Unsurfaced Asphalt strip	0	0	1	0.25	0.50	6.70	5.90	4.00	2.0	2.0	2.4	Failed at 20 coverages due to roughness	
	20	20	2	0.50	0.88	9.70	8.80	6.47	2.4	2.5	2.4		
	50	50	4	0.50	0.94	7.95	5.40	3.00	2.4	2.5	2.4		
	80	80	7	0.50	0.94	7.95	5.40	3.00	2.4	2.5	2.4		
	100	100	11	0.50	0.63	7.95	5.40	3.00	2.4	2.5	2.4		
	120	120	13	0.50	0.63	7.95	5.40	3.00	2.4	2.5	2.4		
	150	150	21	0.50	0.63	7.95	5.40	3.00	2.4	2.5	2.4		
	200	200	21	0.50	0.63	7.95	5.40	3.00	2.4	2.5	2.4		
	300	300	21	0.50	0.63	7.95	5.40	3.00	2.4	2.5	2.4		
	400	400	21	0.50	0.63	7.95	5.40	3.00	2.4	2.5	2.4		

TABLE 2
SUMMARY OF CBR, DENSITY, AND WATER CONTENT DATA
TEST SECTION 2

Test Item*	Type of Surface	Coverages	Depth (in.)	CBR	Water Content (%)	Dry Density (lb/cu ft)	Remarks
Lane 3							
1	Modified Tll aluminum landing mat	0	0	2.4	33.1	84.7	Item failed at 600 coverages due to roughness
			6	2.8	32.6	85.7	
			12	2.4	33.3	85.4	
		200	0	2.1	31.4	86.7	
			6	2.2	32.3	86.1	
			12	2.6	32.6	85.6	
		600	0	2.4	32.0	87.1	
			6	2.2	33.3	85.7	
			12	4.1	32.4	86.5	
2	M8 steel landing mat	0	0	3.4	29.7	89.0	Item failed at 120 coverages due to roughness
			6	3.6	29.9	88.8	
			12	5.9	26.4	94.4	
		122	0	6.3	26.1	93.6	
			6	3.5	30.1	91.2	
			12	7.6	26.9	93.3	
3	Unsurfaced	0	0	12.0	24.5	94.8	Item failed at 60 coverages due to rutting
			6	7.0	26.8	89.1	
			12	12.0	25.5	92.9	
		66	0	9.0	26.6	95.2	
			6	8.0	25.0	97.1	
			12	9.0	26.8	95.8	
Lane 4							
1	Modified Tll aluminum landing mat	0	0	2.4	33.0	84.1	Item failed at 20 coverages due to roughness
			6	3.0	32.7	84.3	
			12	1.5	33.7	84.3	
			18	2.6	36.0	84.5	
		20	0	2.6	27.4	90.9	
			6	2.0	33.5	85.2	
			12	2.5	32.6	86.0	
			18	2.4	30.3	86.7	
2	M8 steel landing mat	0	0	3.5	29.1	88.8	Item failed at 20 coverages due to roughness
			6	1.9	29.5	87.3	
			12	7.0	26.6	93.6	
			18	6.0	28.7	90.8	
		20	0	3.6	30.0	89.8	
			6	3.5	28.4	91.5	
12	4.3	30.0	89.4				
3	Unsurfaced	0	0	12.0	24.5	94.8	Item failed at 20 coverages due to rutting
			6	7.0	26.5	89.1	
			12	12.0	25.3	92.9	
			18	11.0	26.6	94.9	
		20	0	9.0	24.8	96.0	
			6	11.0	24.2	97.3	
			12	8.0	25.5	95.4	
			18	12.0	24.7	95.8	

* Subgrade material was heavy clay (buckshot; classified as CH) in all items.

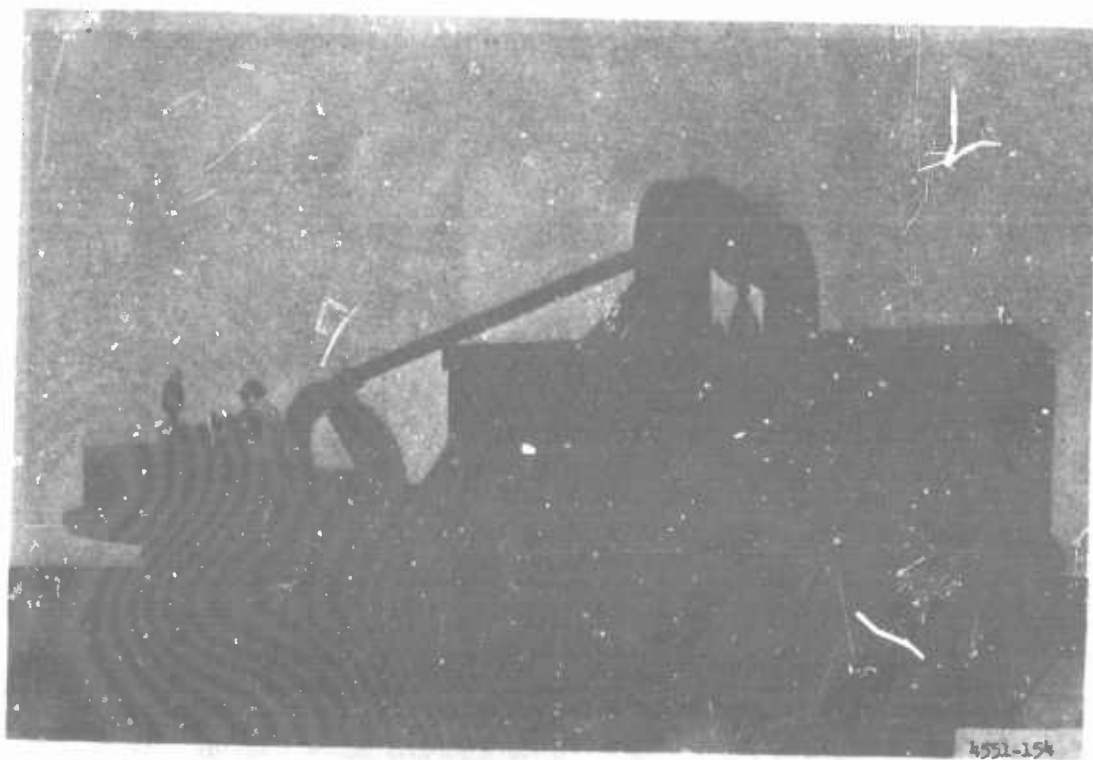


Figure 2. Test load vehicle

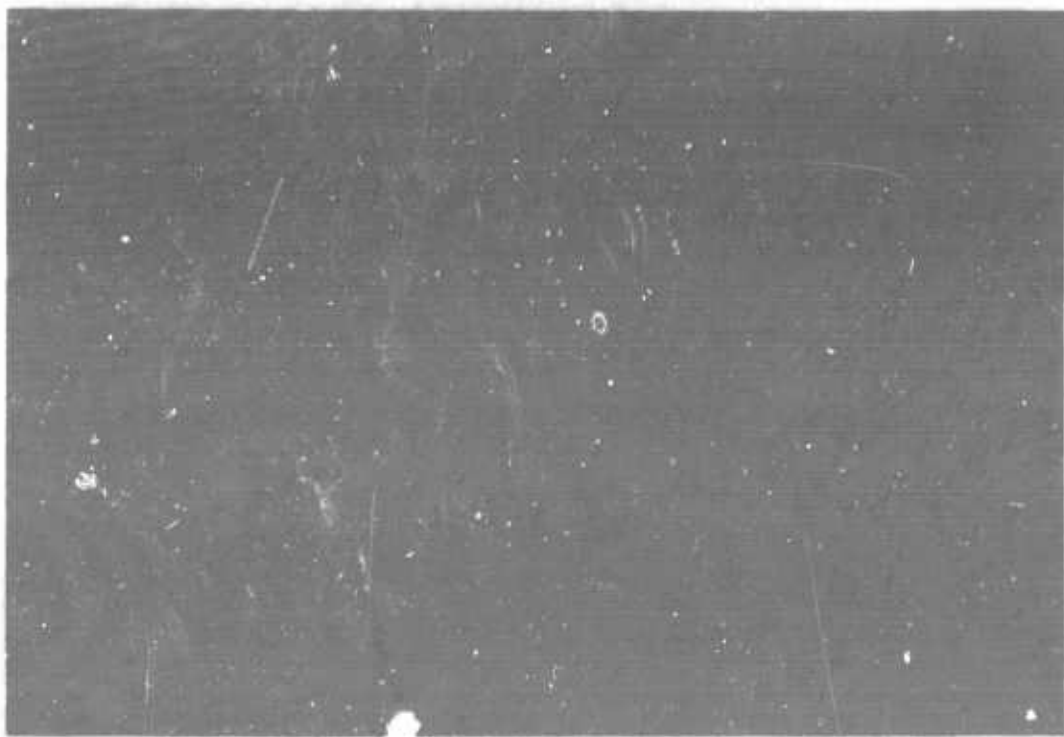


Figure 3. Lane 3, item 1, prior to traffic

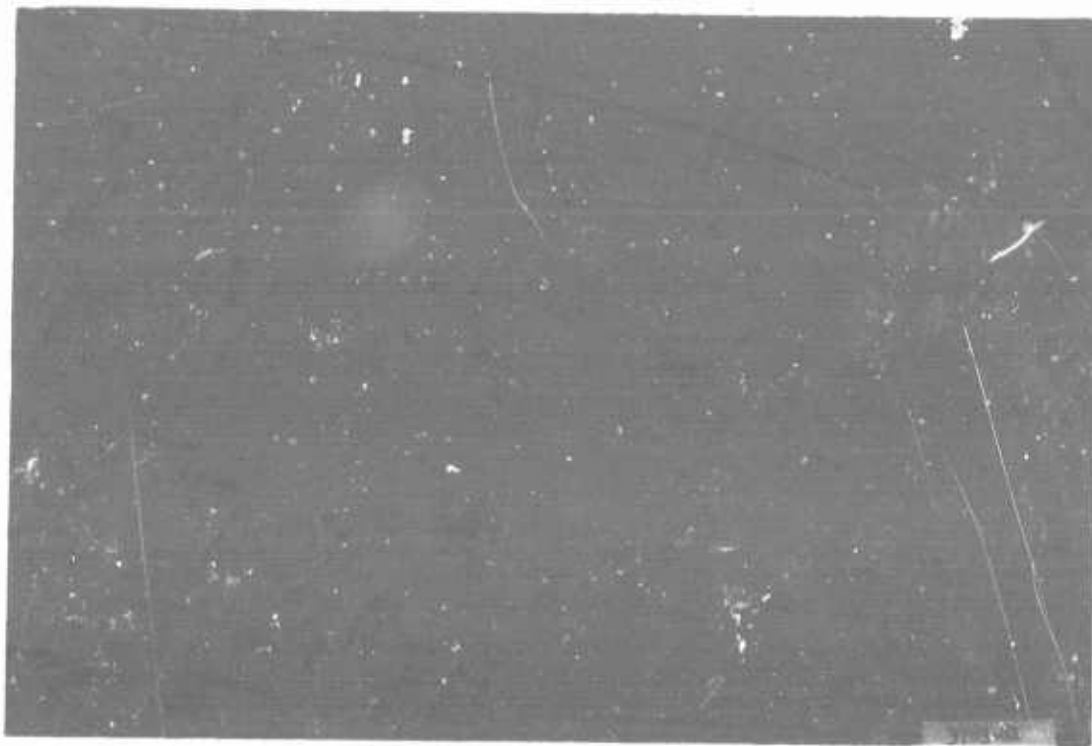


Figure 4. Lane 3, item 1, showing severe localized mat damage at 458 coverages

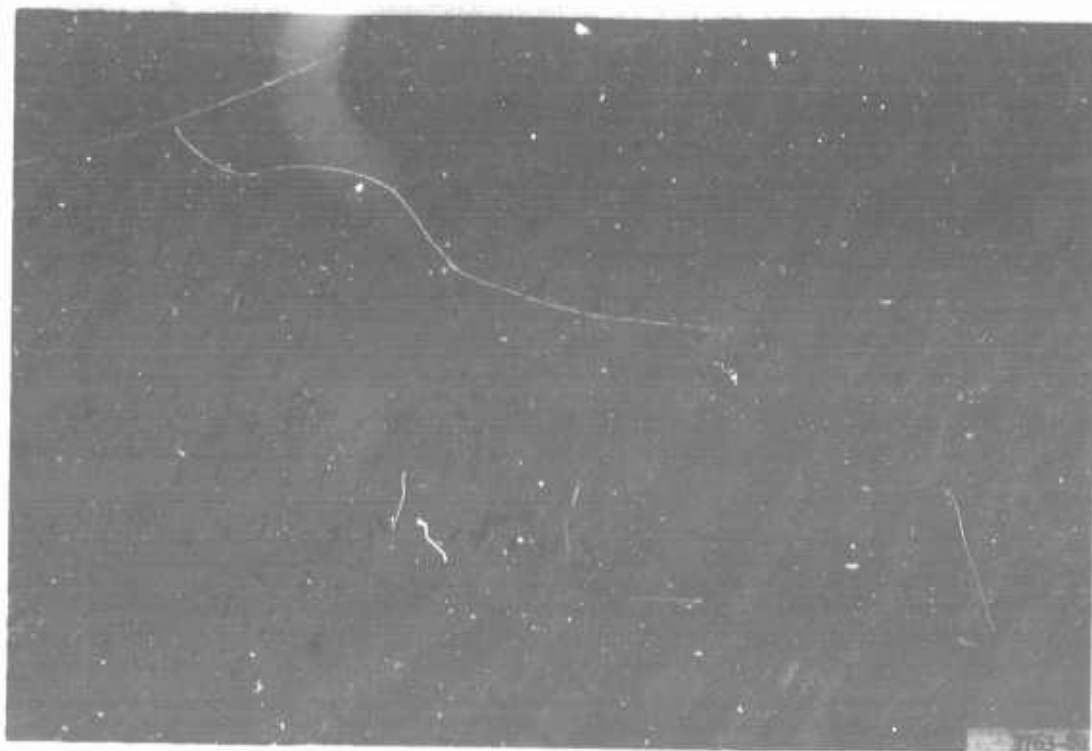


Figure 5. Lane 3, item 1, showing displaced subgrade after mat removal at 458 coverages

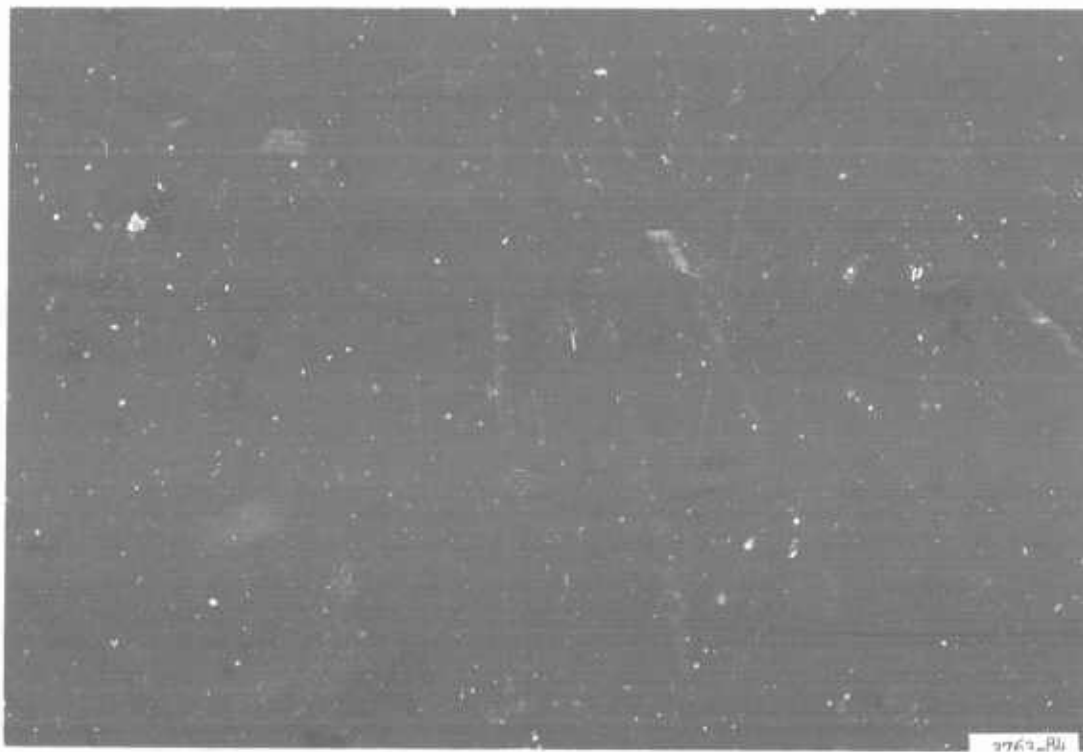


Figure 6. Lane 3, item 1, at 600 coverages (failure)

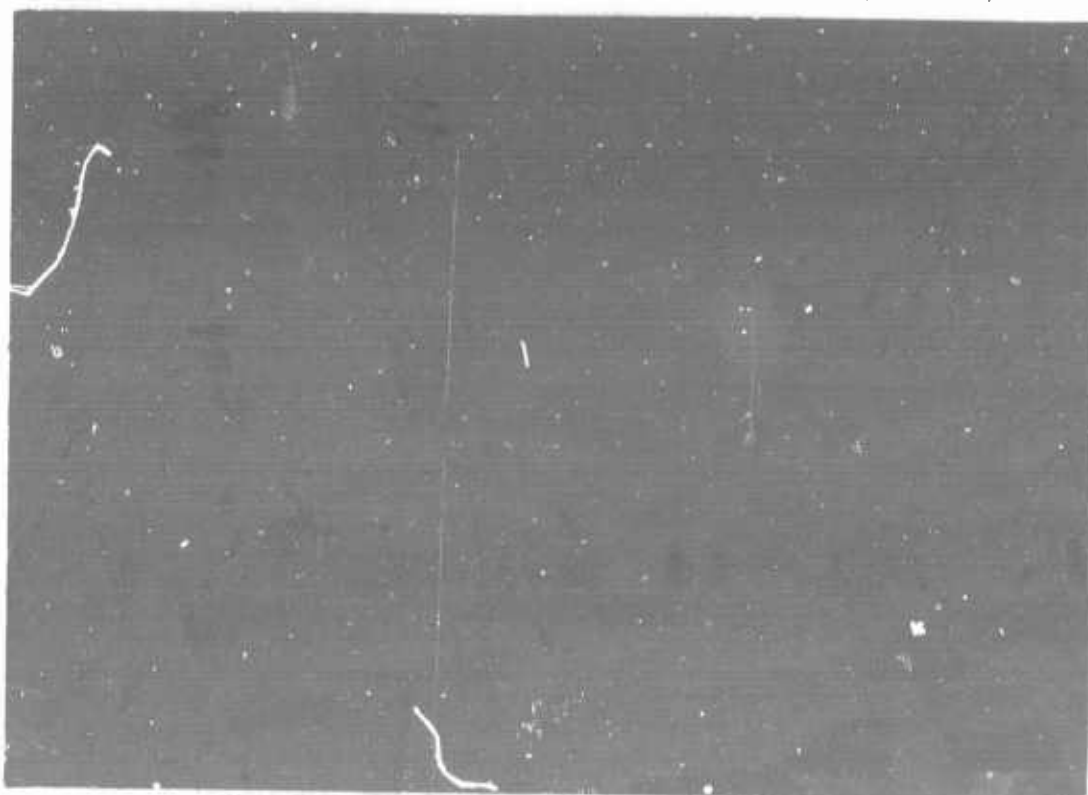


Figure 7. Lane 3, item 1; diagonal straightedge shows roughness at 600 coverages (failure)

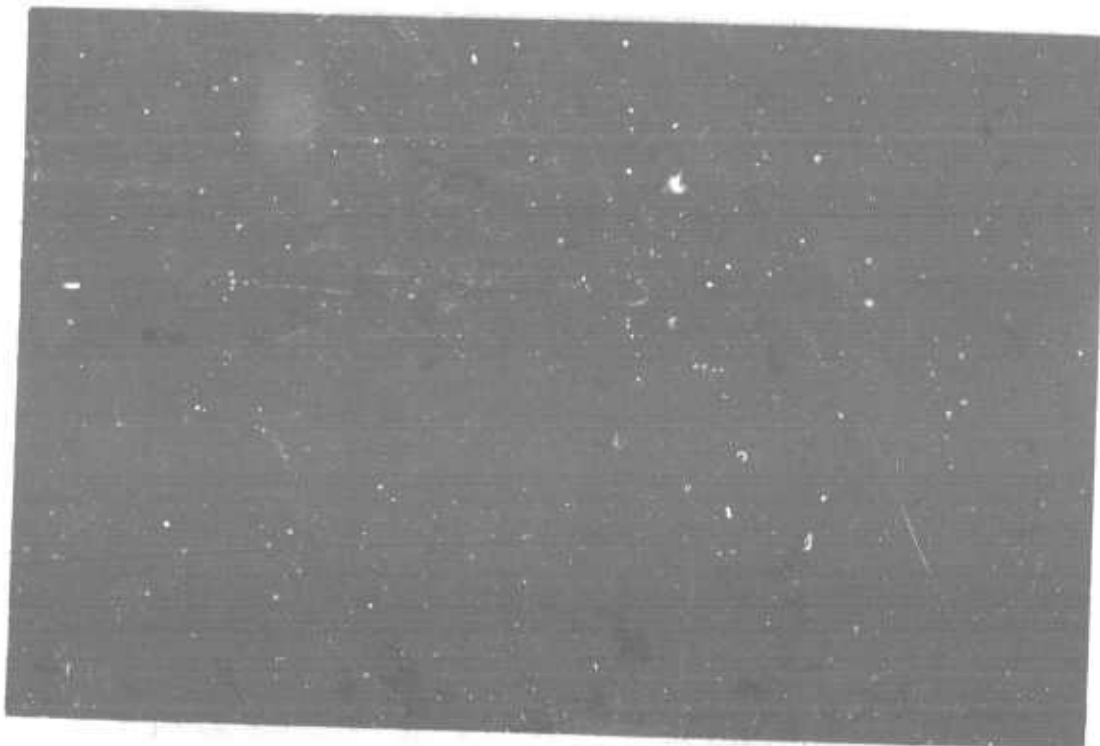


Figure 8. Lane 3, item 2, prior to traffic

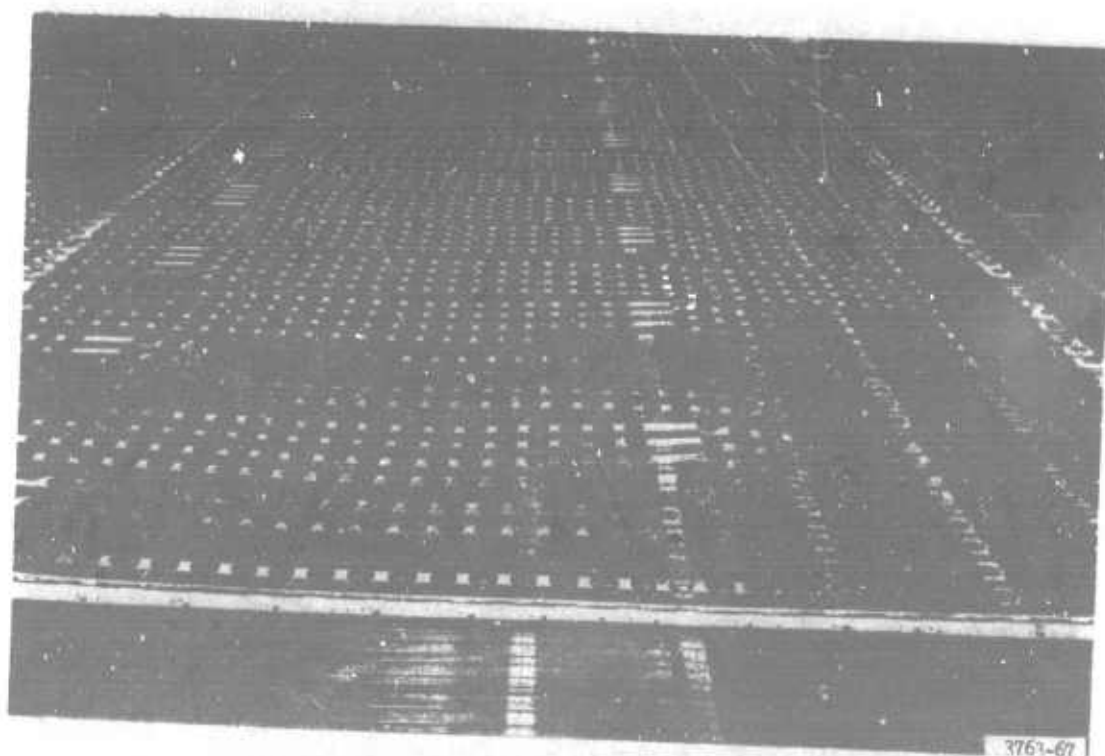


Figure 9. Lane 3, item 2, at 122 coverages
(2 postfailure coverages)



Figure 10. Lane 3, item 2; diagonal straightedge shows roughness at 122 coverages (2 postfailure coverages)



Figure 11. Lane 3, item 2; diagonal straightedge shows roughness at 280 coverages (160 postfailure coverages)

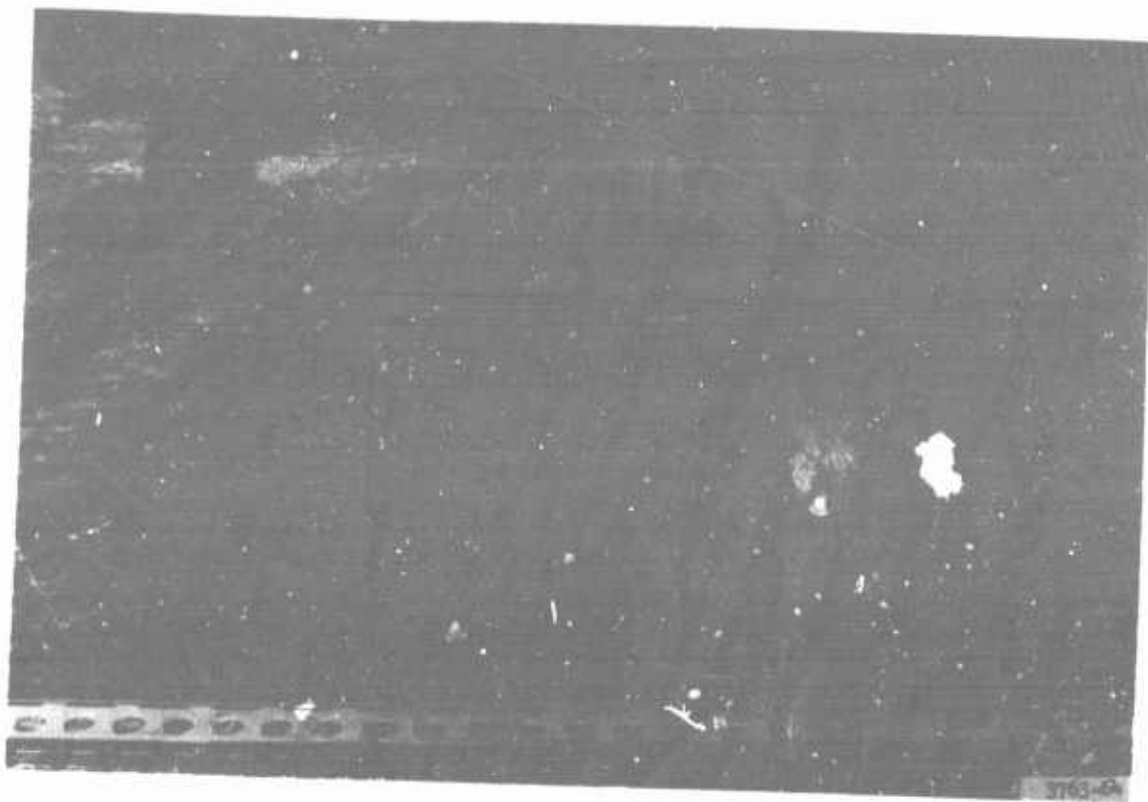


Figure 12. Lane 3, item 3, prior to traffic

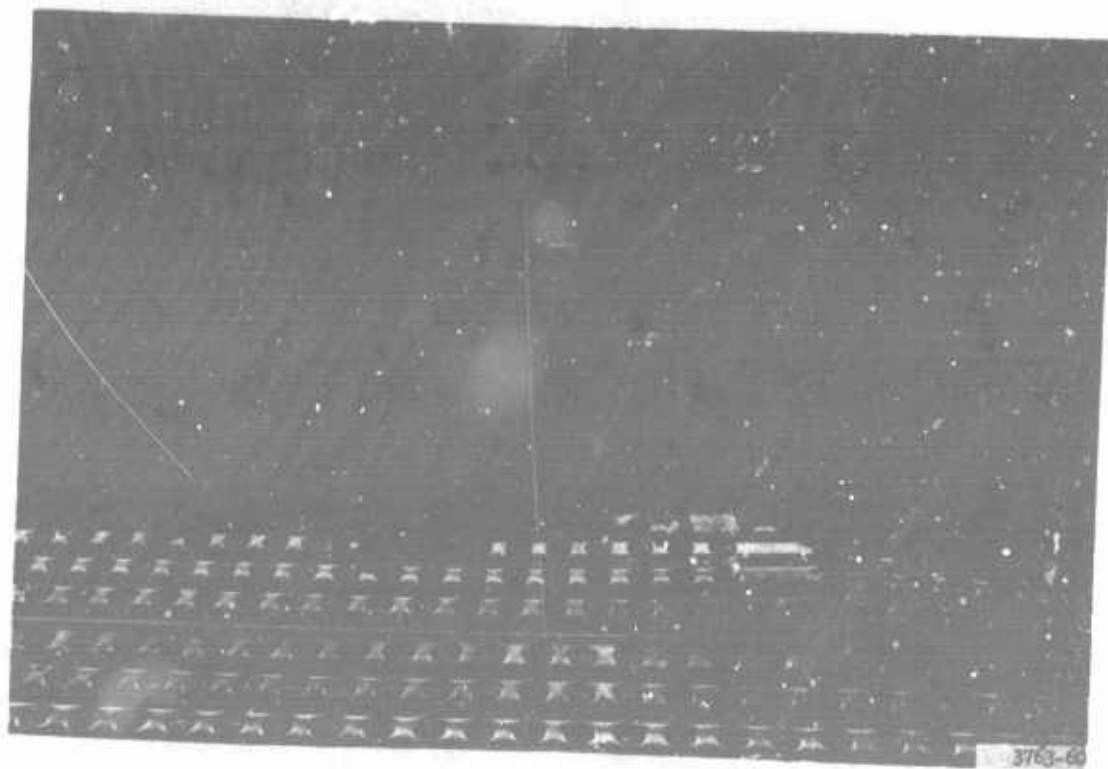


Figure 13. Lane 3, item 3; transverse straightedge shows roughness at 20 coverages



Figure 14. Lane 3, item 3; transverse straightedge shows roughness at 60 coverages (failure)

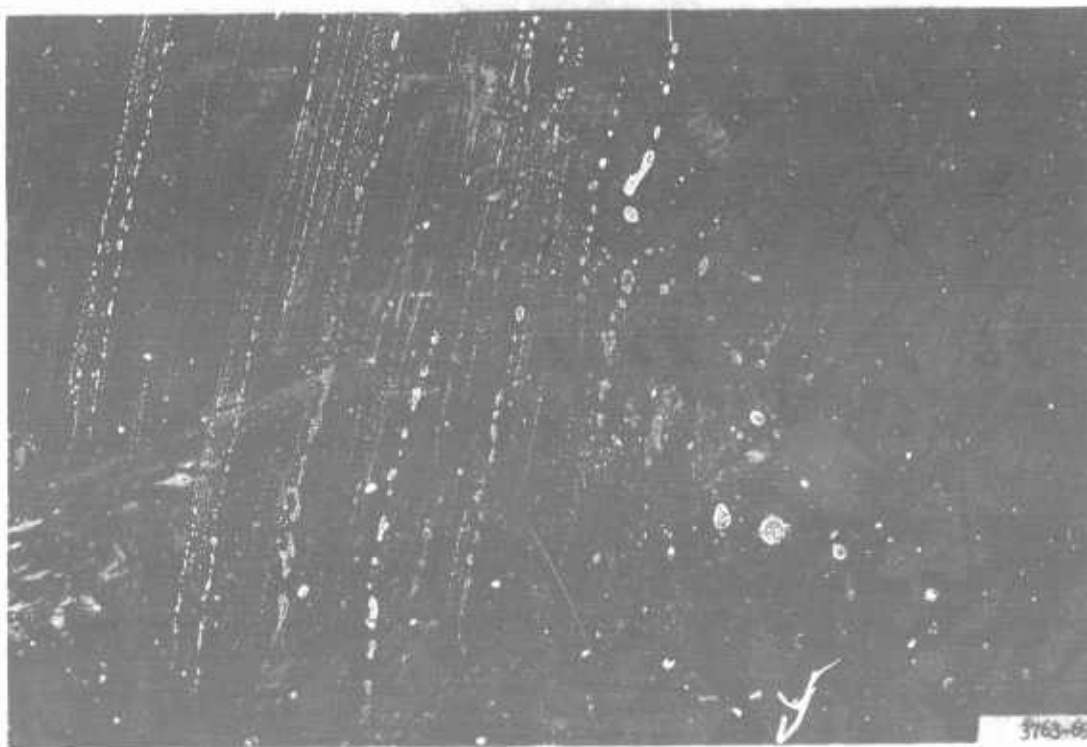


Figure 15. Lane 3, item 3, at 122 coverages (62 postfailure coverages)

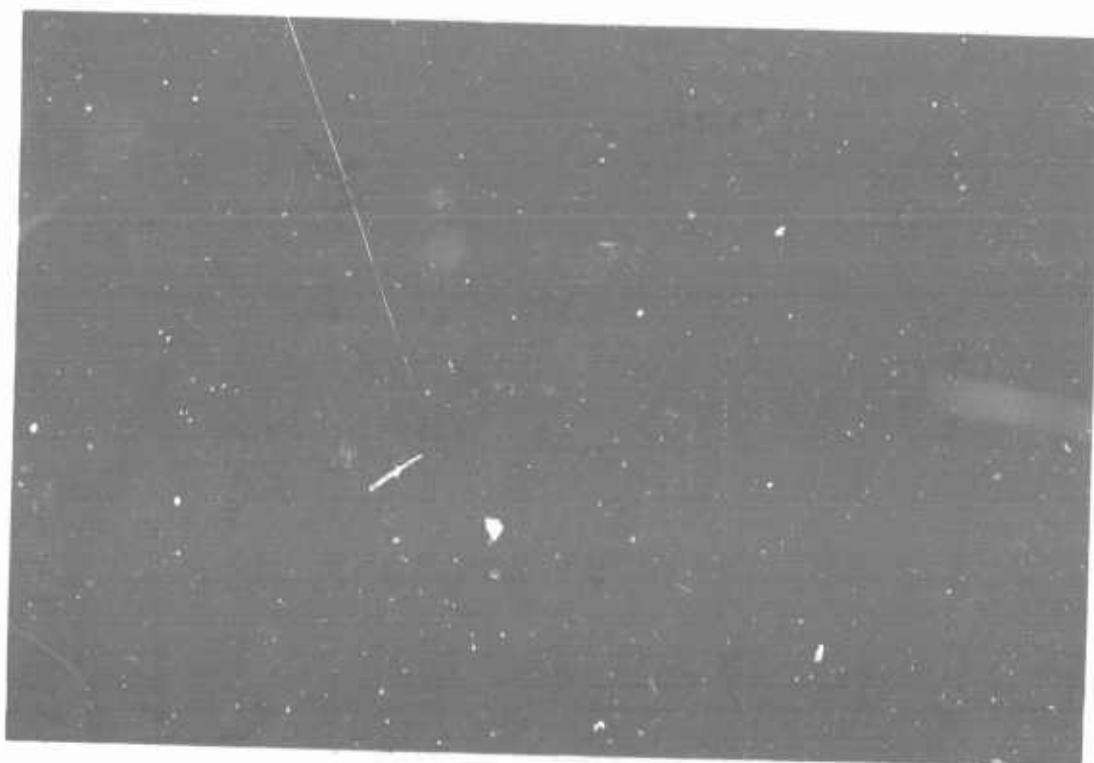


Figure 16. Lane 4, item 1, prior to traffic

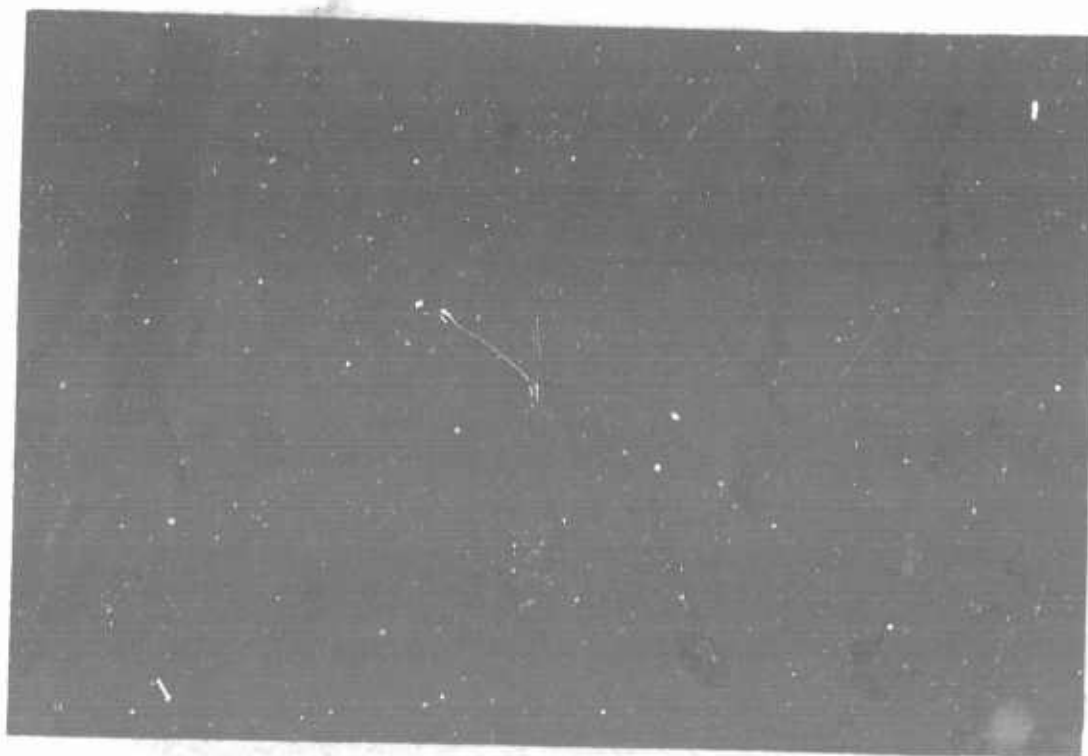


Figure 17. Lane 4, item 1, at 20 coverages (failure)



Figure 18. Lane 4, item 1, broken panel in run 15 at 20 coverages (failure)

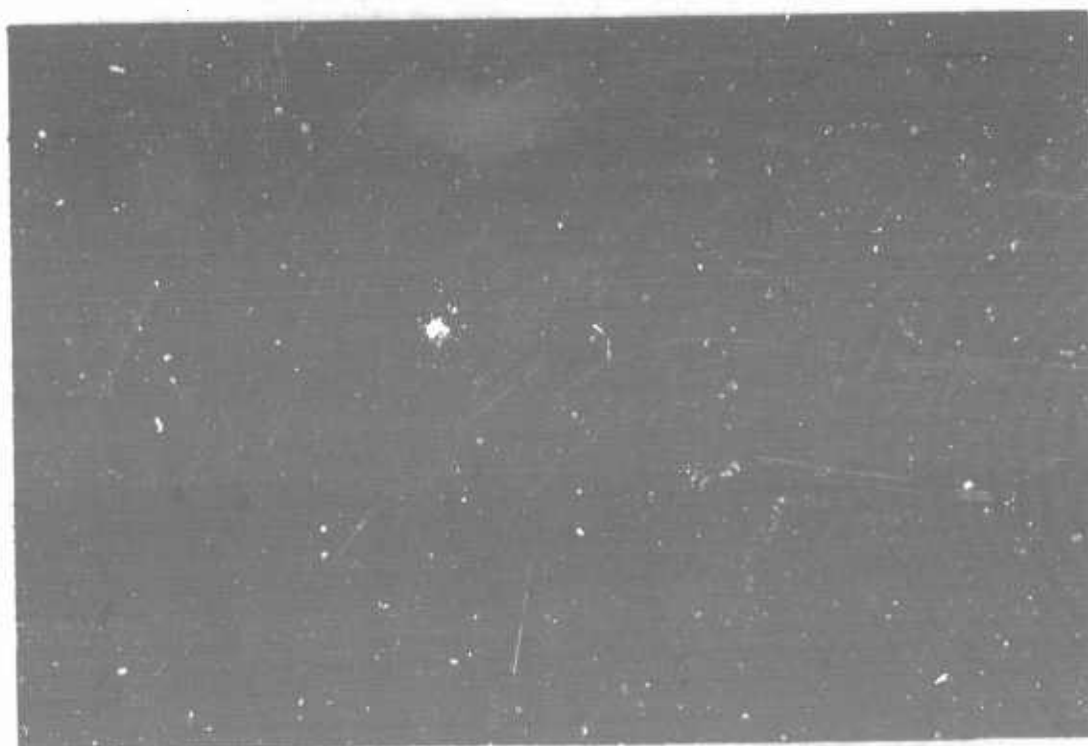


Figure 19. Lane 4, item 2, prior to traffic

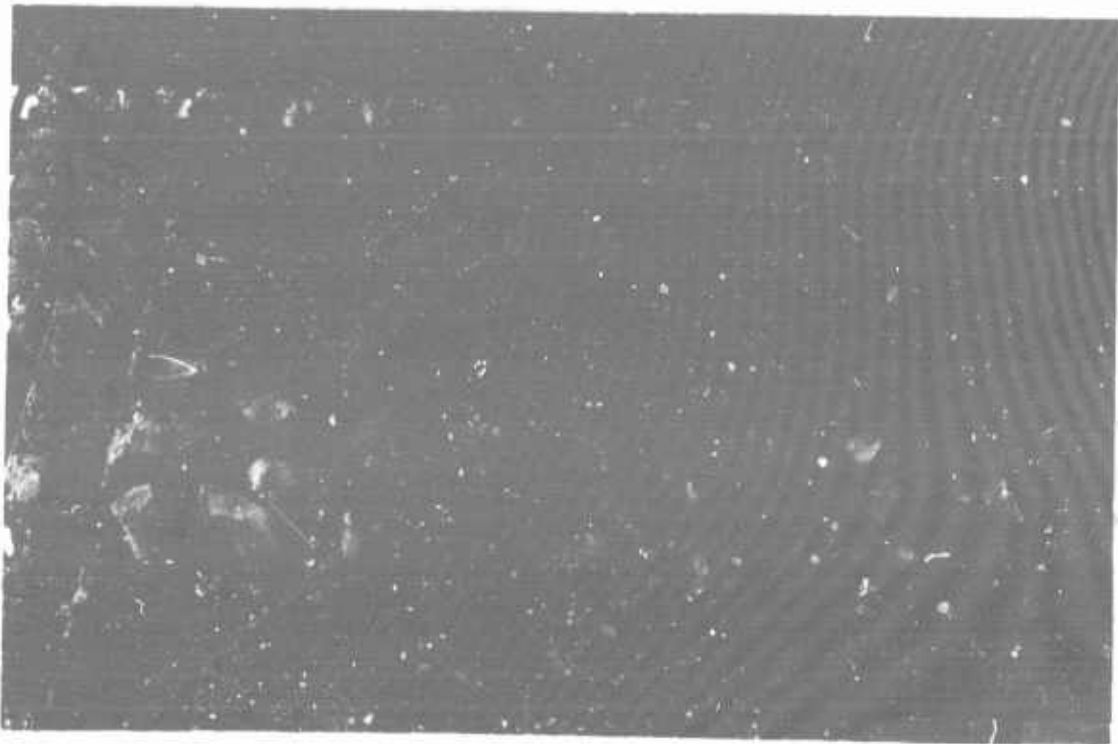


Figure 20. Lane 4, item 2, after two passes of load vehicle, showing extruded soil

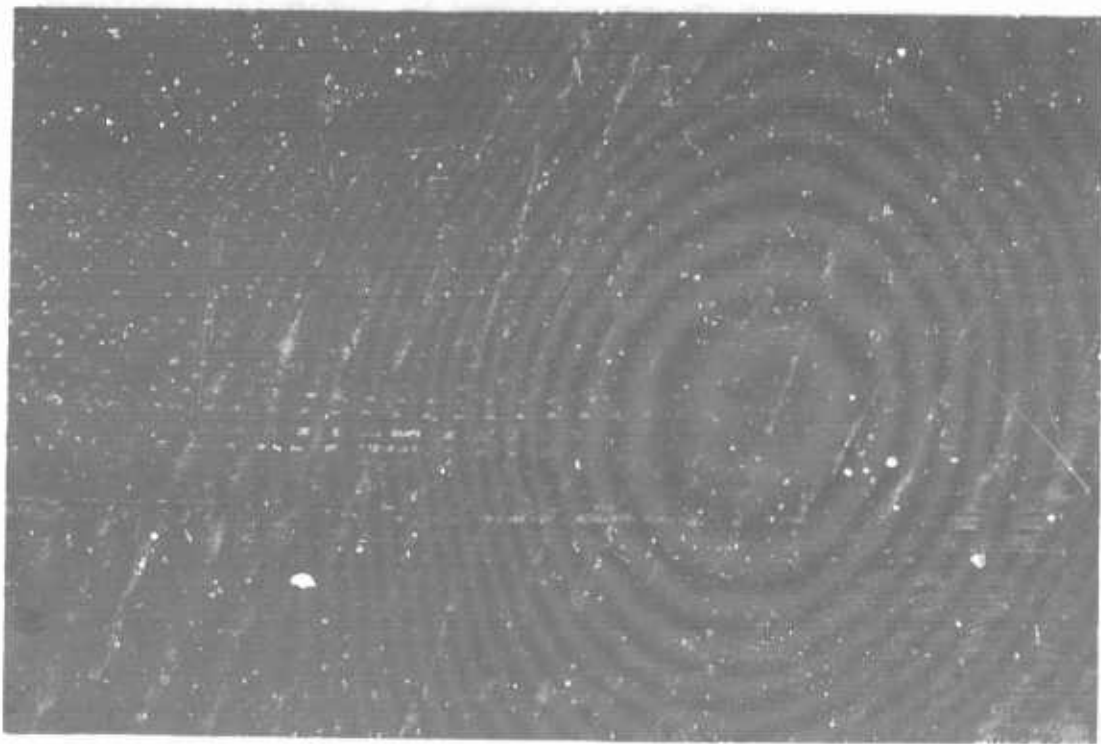


Figure 21. Lane 4, item 2, at 20 coverages (failure)



Figure 22. Lane 4, item 2; diagonal straightedge shows roughness at 20 coverages (failure)

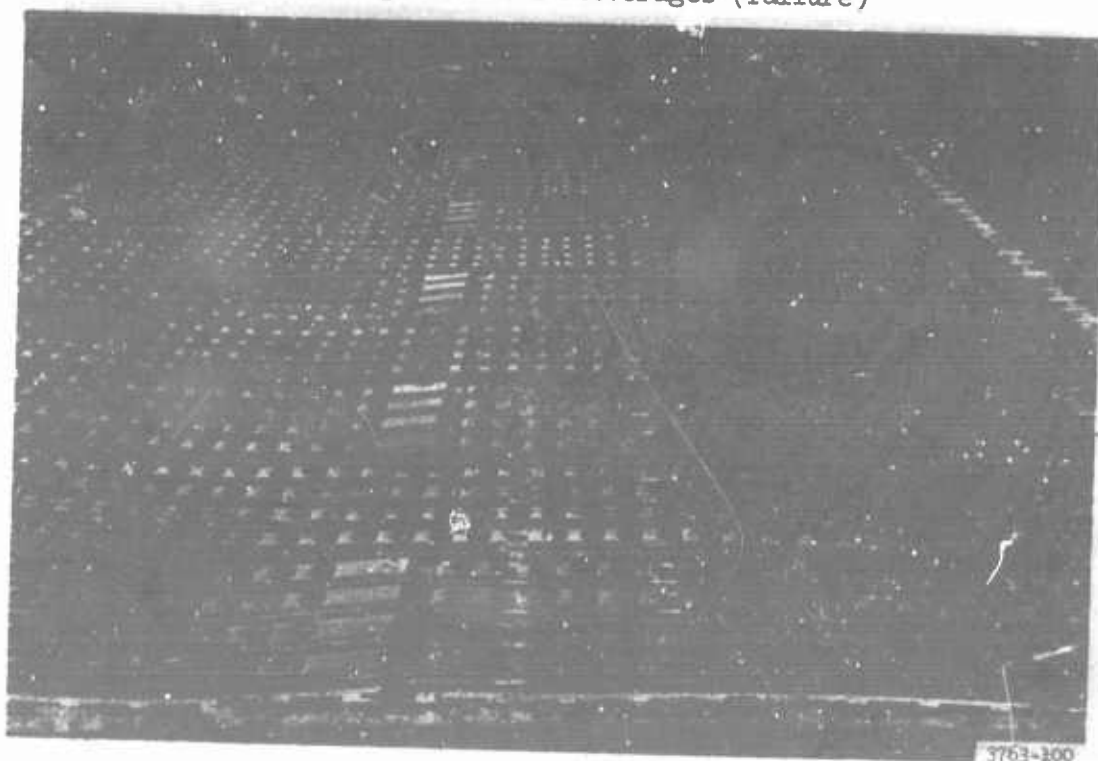


Figure 23. Lane 4, item 2, at 20 coverages (failure) after removal of extruded soil

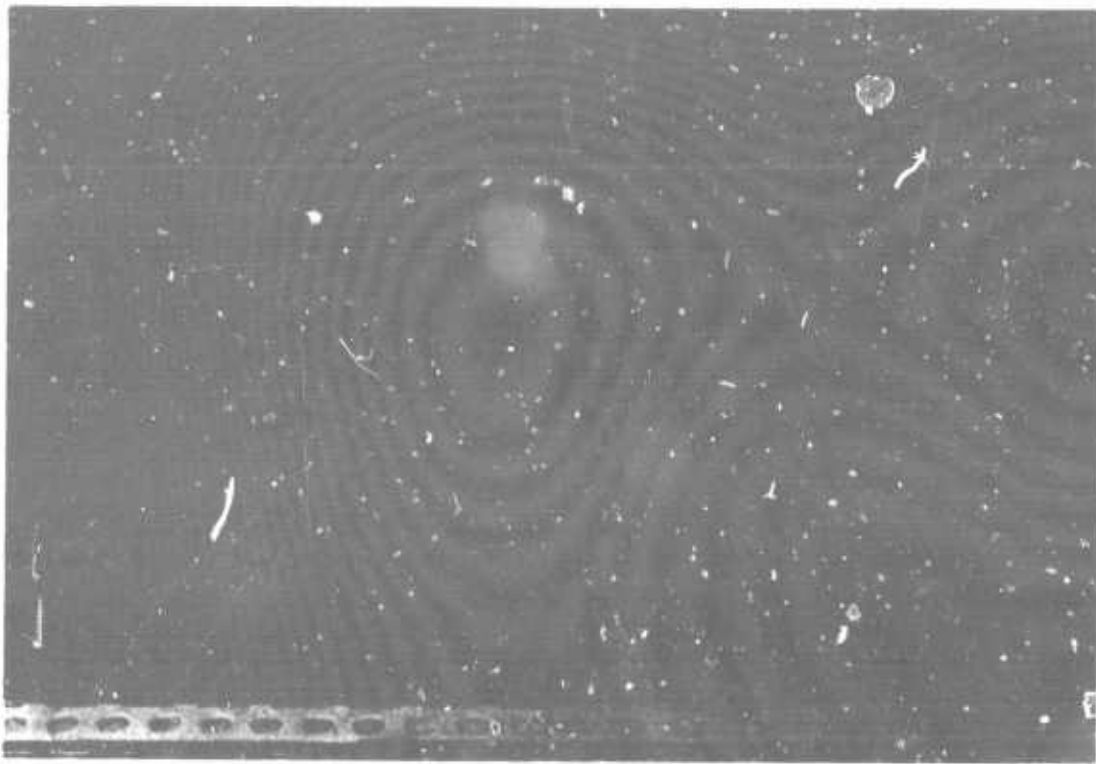


Figure 24. Lane 4, item 3, prior to traffic

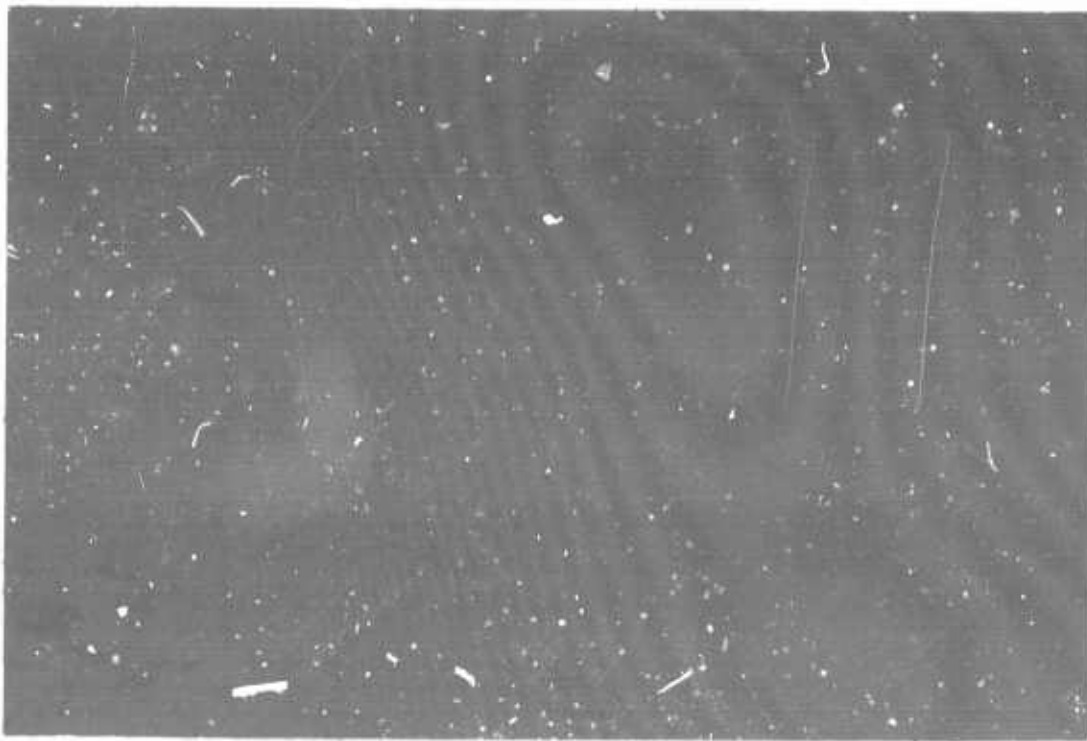


Figure 25. Lane 4, item 3; transverse straightedge shows rutting at 20 coverages (failure)

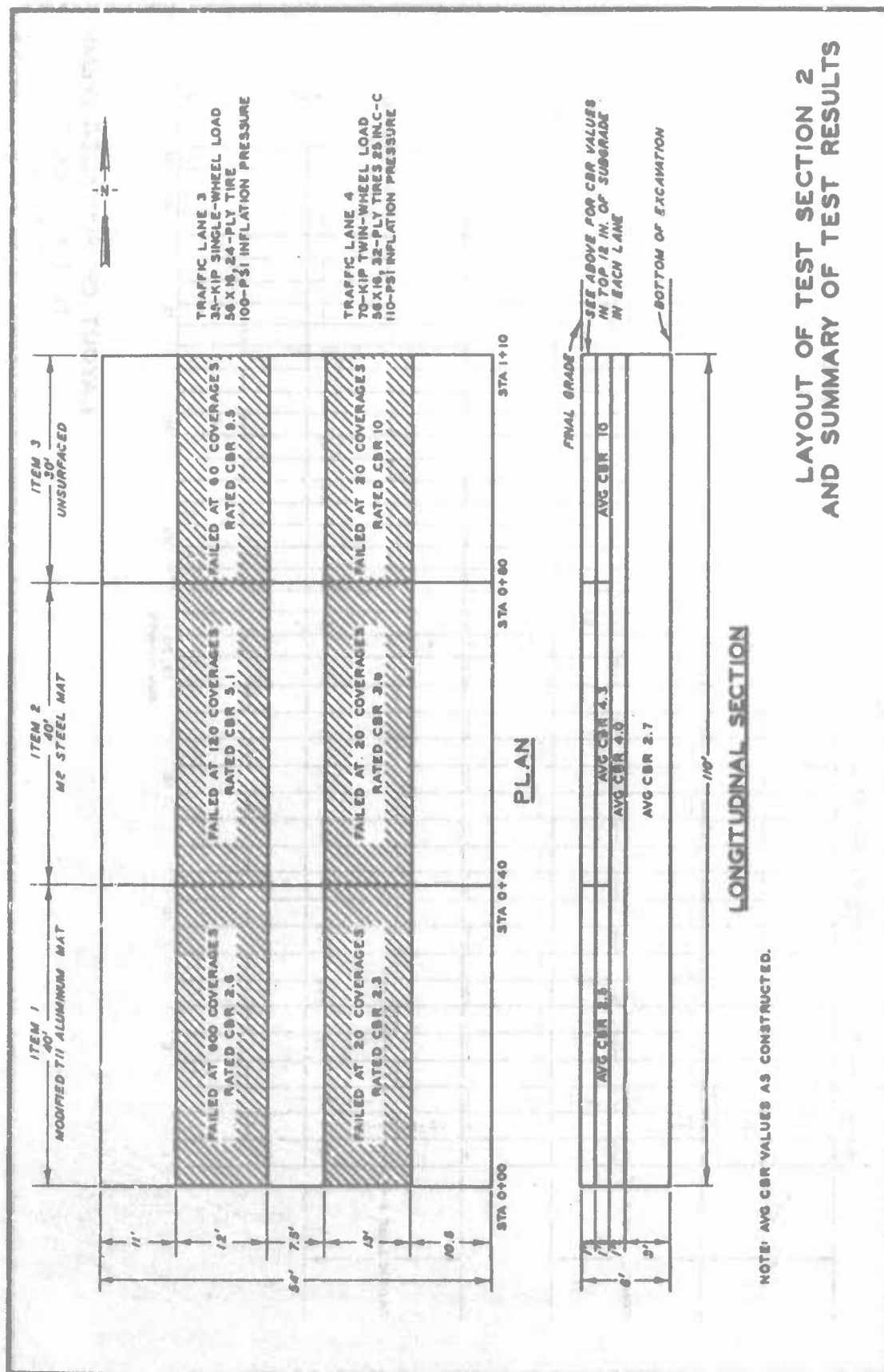
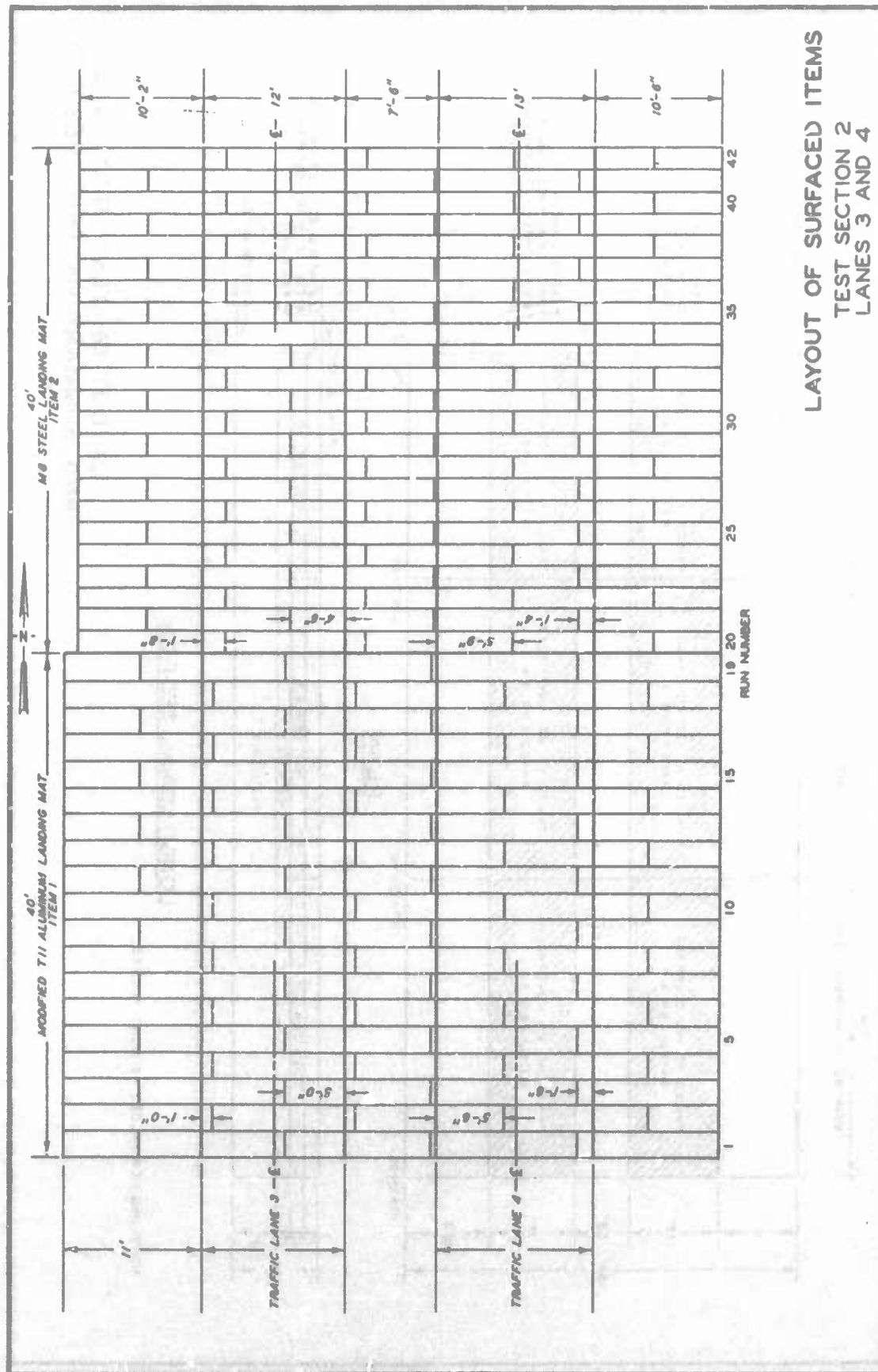


Figure 26



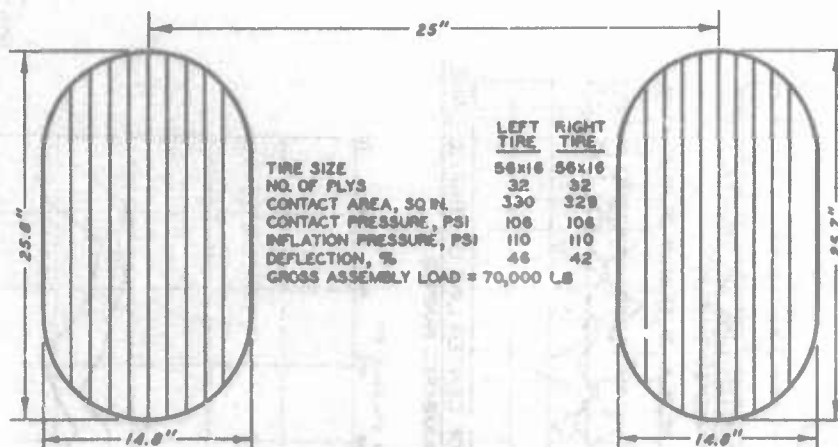
LAYOUT OF SURFACED ITEMS
TEST SECTION 2
LANES 3 AND 4

Figure 27



TIRE SIZE	56x16
NO. OF PLYS	24
CONTACT AREA, SQ IN.	318
CONTACT PRESSURE, PSI	110
INFLATION PRESSURE, PSI	100
DEFLECTION, %	40
GROSS ASSEMBLY LOAD = 35,000 LB	

LANE 3



LANE 4

**TIRE-PRINT DIMENSIONS AND
TIRE CHARACTERISTICS**

**TEST SECTION 2
LANES 3 AND 4**

Figure 28

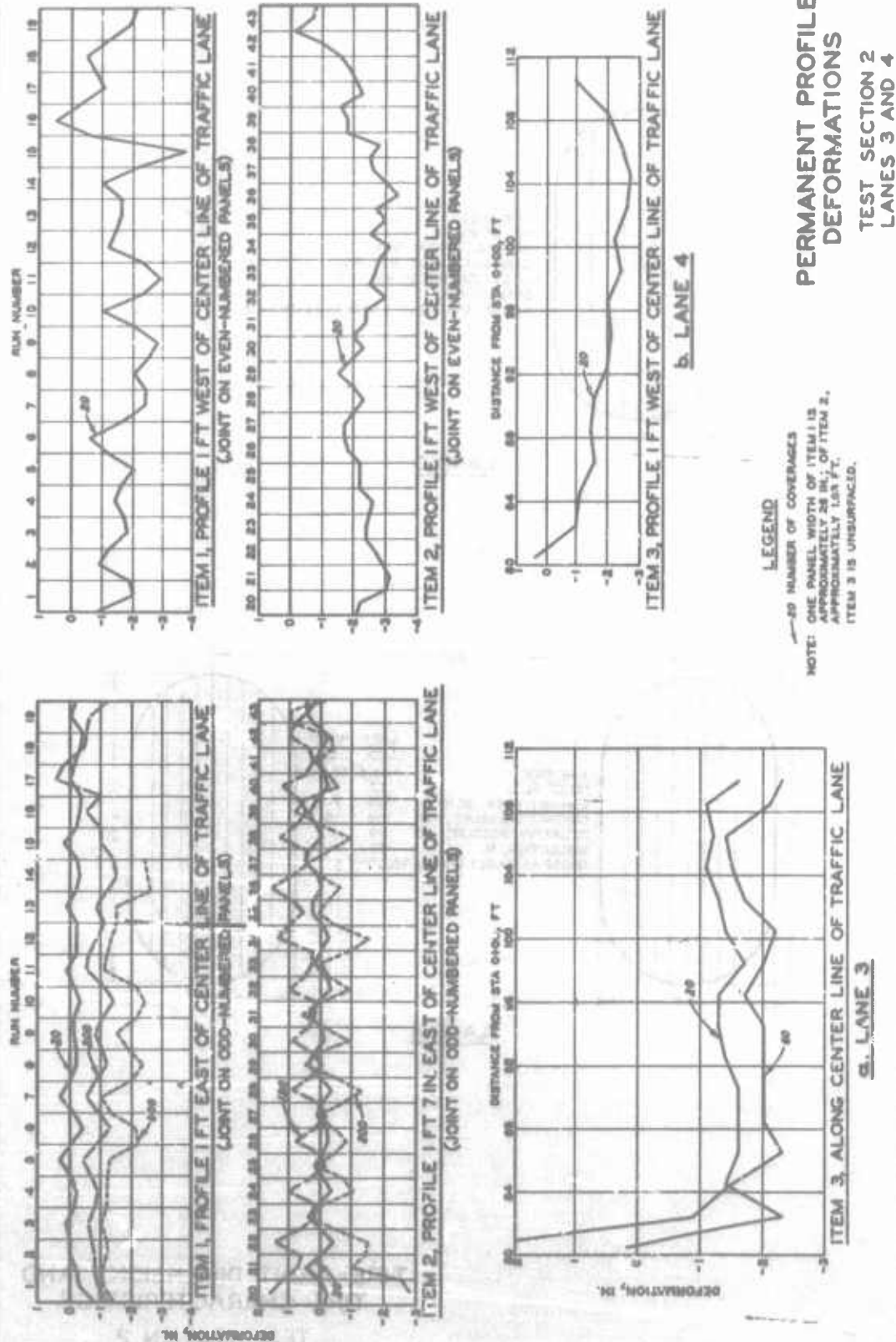


Figure 29

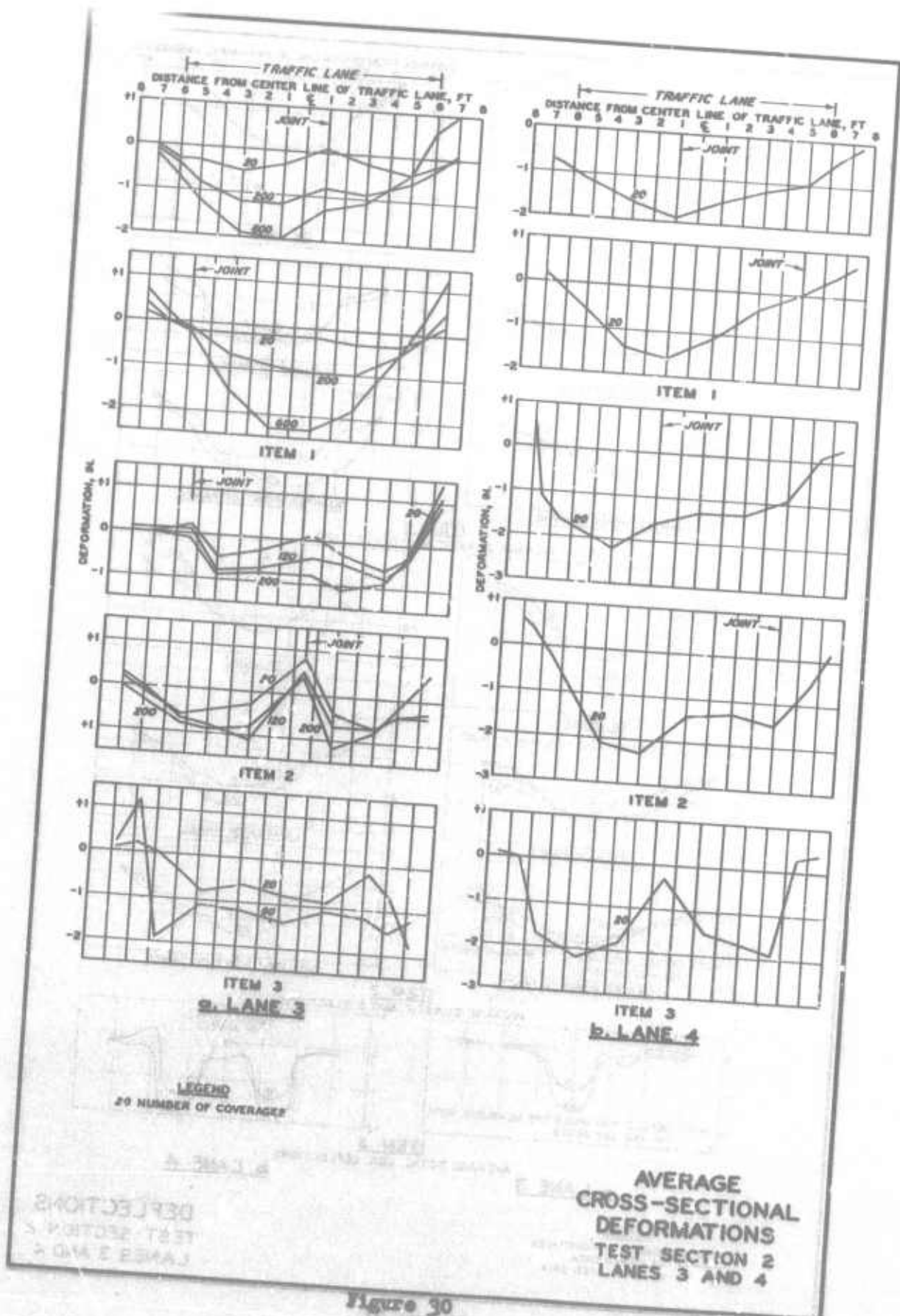
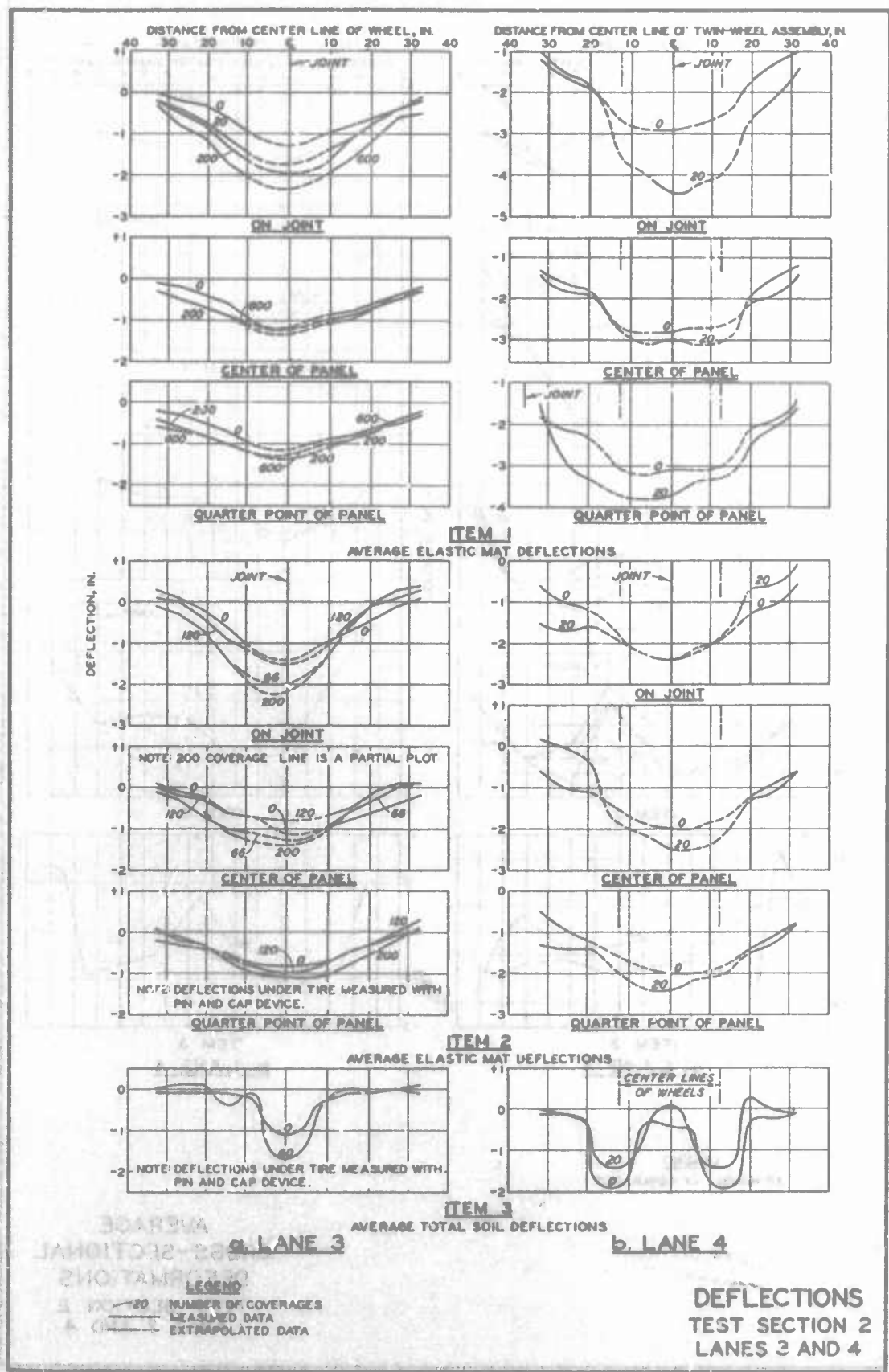


Figure 30



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DOCUMENT CONTROL DATA - R&D

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station		2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	
		2b. GROUP	
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11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY Air Force Flight Dynamics Laboratory Research and Technology Division AF Systems Command, WPAFB, Ohio	
13. ABSTRACT This data report describes the results of work undertaken as part of an overall program to develop ground-flotation criteria for the C-5A aircraft.			

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14. KEY WORDS	LINK A		LINK B		LINK C	
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